

## LESSON 17 SPECIAL FINISHES

- of the ignition source." The material that is flame resistant may be a polymer, fiber, or fabric.
2. Use of the terms *flame retardant* and *self-extinguishing* is discouraged (ASTM 1998, 23, 40). *Flame-retardant treated* and *flame-retardant treatment* are, however, acceptable terms and *flame retardant* is used in other countries. ASTM does not approve the use of the term *self-extinguishing* to describe a textile product because it is meaningful only when applied to specific circumstances.
  3. A *thermally stable* material (fiber or polymer) is one that has a high decomposition temperature and is thus inherently flame resistant because of chemical structure (rather than through the presence of added flame-retardant treatments) (Clark and Tesoro 1974).

### Flame-Resistant Textiles

Textile products can be made flame resistant by using fibers that are inherently flame resistant or by application of a flame-resistant finish. Modacrylic fibers offer adequate flame resistance at a moderate cost and have some use in carpets, curtains, and children's sleepwear. Many other synthetic fibers shrink from ignition flames, providing some protection. Untreated polyester and nylon, for example, will pass the test for children's sleepwear based on this characteristic.

The more thermally stable materials such as asbestos, glass fiber, the aramids, PBI, and PBO could be called fireproof substances that will not burn. Glass fiber has many industrial uses and may be used to a limited extent in household textile products such as window shades or lamp shades. Thermally stable synthetic fibers have not been developed for general use but rather are intended for specialized protective clothing for industrial and military uses. Not only are they expensive, but they also lack the aesthetic features that would make them useful in consumer products.

For fibers that are not flame resistant, a flame-retardant treatment can be applied. Durable finishes for cotton and cotton blend fabrics contain phosphorus which reacts chemically with the fibers and inhibits the production of compounds that fuel the flame. Commercial flame-retardant finishes are Pyrovatex, Proban, and Py-ron, the latter produced by Ciba Chemicals.

Finishes for synthetic fibers have bromine that quenches the flame by reducing the generation of flammable gases. Tris-2, 3-dibromopropyl phosphate (TRIS) was used for several years to impart flame resistance to nylon and polyester, but was suspected of causing cancer in laboratory animals. Since its removal from the market, and modifications in the test procedure for children's sleepwear, nylon and polyester are not usually finished with a flame-retardant treatment.

A particular problem in textile flammability is the burning of cotton/polyester blends. Since polyester is less flammable than

cotton, one would expect blended fabrics to be less hazardous than all cotton fabrics. This is unfortunately not the case, because the char left as the cotton burns serves to hold the melting and dripping poly-ester in the flame. This is referred to as a "scaffolding" effect that prevents the polyester from dripping away, as it would do in a 100 percent polyester fabric. The polyester remains in the flame and contributes to the burning.

Wool is inherently moderately resistant to burning and provides some protection in apparel and interior furnishings. For more stringent uses such as airplane seats, however, wool is given a flame-retardant treatment. A common finish for wool is Zirpro. performance standards that materials are required to meet are set forth in the CFR. These tests described above usually have a single pass/fail criterion. A wide variety of additional tests for flammability can be conducted to provide information on burning behavior and effectiveness of finishes.

Many of these methods require test samples of considerable size or even whole garments. DuPont, Eastman Kodak, and the University of Minnesota have developed thermal testing manikins with heat sensors located in various parts of the figure. Tests performed using these figures can determine not only the combustibility of the fabric being tested but also the location of hot spots and can furnish data about the transfer of heat. They can also assess effects of fabric layers such as a cotton dress worn over a nylon slip.

There are tests for carpets other than the pill test required by the federal standard. The Flooring Radiant Panel Test is said to simulate conditions of interior fires more effectively than other carpet tests. As a result, it is likely to be used by governmental and other regulatory agencies that require the more extensive product evaluation that carpeting installed in hospitals and facilities participating in Medicare and Medicaid programs must meet.

An area of considerable interest in flammability testing of interiors is computer simulation or virtual tests to determine the hazards of real-life situations. For example, data on the furnishings in a prototype room can be used to predict the results of a fire (Gorman 1994). More realistic measures of fire hazards can be obtained and used in such predictive models. These measures, including total heat release, rate of heat release, and toxic gases evolved, are the real dangers from fires involving textiles.

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resin holds yarns together at the points where the yarns interlace. Resin antislip finishes are durable.

Other antislip finishes can be created by coating silica compounds on fabrics. However, these finishes are only temporary.

#### Temperature-Regulating Finishes

Temperature-regulating fabrics are sensitive to the surrounding temperature or to body heat. Finishes that provide this adaptation include substances called phase change materials (PCMs) (Lennox-Kerr 1998). These substances change from solid to liquid or liquid to solid depending on the temperature. The example we are probably most familiar with is ice changing to water when the temperature rises and then changing back to ice again when cooled. Ice absorbs heat to melt and water gives off heat when it becomes solid. PCMs work the same way but are selected to undergo this phase change around normal skin temperature.

One such finish is polyethylene glycol (PEG), which is applied to fabrics along with a methylol agent such as DMDHEU. The result is a network polymer that is insolubilized on the surface of the fibers. The polymer absorbs and holds heat energy at high temperature, and then releases the stored energy under cooler conditions. The finish is durable to wear and laundering, because it is cross linked on the fabric.

Not only do these finishes help to warm or cool the body, but they also increase the moisture absorbency of fabrics, thereby further enhancing comfort. Other improved properties are resistance to static, wrinkling, abrasion, pilling, and soil. The PEG finish has been used on T-shirts, underwear, socks, activewear, and biomedical products.

In another form, PCMs have been applied to fabrics as microcapsules in coatings, used in nonwoven bonding materials, or included in spinning solutions of manufactured fibers. Outlast Technologies, Inc. produces the microcapsules. Acordis Fibers has produced a version of their Courtelle acrylic fibers with the PCM embedded in them. The fabrics made with these fibers are targeted for outdoor apparel, particularly for cold climates. PCM-containing textile fabrics are expensive because the encapsulation process is technology intensive.

#### Heat-Reflectant Finishes

An increased level of insulation can be provided in garments and draperies by the addition of heat-reflectant finishes. Most of these products are treated with a spray coating of metal and resinous substances. The heat-reflectant material is sprayed onto the surface of a closely woven fabric. The finish is designed to keep heat either on one side or the other side of the fabric. The finish is effective only with radiated heat.

Lining fabrics are usually constructed so that the finish is applied to the inside of the fabric. The finish reflects the body heat back toward the wearer, thus providing added warmth. In protective clothing to be worn under hot conditions, the finish is worn to the outside to deflect heat away from the body.

Draperies may also be treated to provide greater insulation for homes. Treated draperies placed inside windows may serve to keep heat inside the home or to reflect heat outward, preventing it from warming the house.

Some of the processes designed to produce heat reflectance use aluminum in the finish, because it provides excellent reflectancy. A variant of this principle is utilized in fabrics coated or laminated with a thin layer of aluminum, foams, resins, or synthetic rubber.

#### Light-Reflectant Finishes

Light-reflectant finishes are created by the application of microscopic reflective beads to the surface of a fabric. The increased number of persons who jog or ride bicycles after dark is probably responsible for the application of this finish to a variety of garments for sports and to other items such as backpacks. A reflective finish called Scotchlite is produced by the 3M Company. The manufacturer notes that the finish does not alter the color or appearance of the garment by day, but after dark the fabric "lights up" when directly in the path of the lights of an oncoming vehicle.

#### Light-Resistant Finishes

Many textile fabrics are deteriorated by exposure to sunlight, so attempts have been made to protect fabrics from light damage. Of all the types of rays in the sun's spectrum, ultraviolet rays are the most destructive of fibers. Although antilight finishes have yet to be perfected, those that are being tried either coat the fabric or impregnate the fibers with materials that absorb ultraviolet rays but are not themselves damaged by or removed by exposure to these rays. Such finishes are particularly important in olefin fabrics, which are degraded by sunlight unless ultraviolet stabilizers are added. Such additives to olefin fibers are permanent and are not lost during usage. Synthetics that have been delustered with titanium dioxide are especially subject to damage from sunlight. This chemical apparently accelerates damage to the fiber and fading of dyes. The addition of certain chemical salts to the melt solution before spinning can ameliorate this problem.

The relationship between exposure to the ultraviolet light of the sun and skin cancer is well known. Many people assume that fabrics prevent exposure to any part of the body that is covered; however, research shows that fabrics do allow passage of ultraviolet light. Knitted fabrics, which usually have a more open structure, generally allow more ultraviolet light through than woven fabrics; lightweight summer fabrics allow more ultraviolet light to reach the skin than heavier fabrics with more opaque yarns.

Ultraviolet protection is now being built into fibers and fabrics. Most of the techniques are proprietary processes, so details of how the protection is provided are limited. Kuraray, a Japanese firm, produces Esmo, a polyester staple fiber to which powdered ceramics have been added to absorb and reflect ultraviolet rays. A similar fiber called Aloft is produced

by the Japanese firm Toray, and other Japanese firms produce fabrics that are given special protective finishes. Australian researchers have developed a chemical finish called Rayosun that is said to be washfast, colorfast, and lightfast. The finishing material contains a "two-part molecule," one part of which absorbs ultraviolet rays while the other part reacts with the fabric, thereby making the finish durable (Sun-proof clothing 1993, 72).

### Other Specialty Finishes

Several additional finishes produce special effects. In one, a powdered material is applied to fabrics to decrease the loss of body heat. In another, the finishing material contains microencapsulated fragrances that gradually release perfumed oils as the fabric is abraded during wear. The scented finishes have been used in fabrics for men's suits. New, too, are finishes for odor control. These compounds entrap the volatile molecules that cause unpleasant odors.

The preparation steps for fabrics are highly dependent on the fiber content. Natural fibers have impurities such as grease and vegetable matter in wool, gum in silk, or vegetable matter and waxes in cotton. Optimum conditions for spinning fibers into yarns, however, require some lubrication of fibers. Also, in synthetic fibers some means must be found to decrease the static electricity that builds up during spinning. For these reasons, natural lubricating substances in cotton are not removed before spinning, and other fibers generally have had

### Notes